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Risk Assessment for Nuclear Waste Management

Description

Risk assessment, primarily in the specialized form called "performance assessment," is a vital component of Sandia National Laboratories' Nuclear Waste Management Program. This program is helping the Nation to solve the problems associated with the disposal of spent fuel from reactors, high-level waste, transuranic waste, mixed wastes, and special wastes from defense programs. The disposal of these wastes poses many challenges. The federal, state, and local regulations governing the disposal are complex, as are the technical questions they raise. To help several projects comply with these regulations, we apply capabilities developed earlier in nuclear weapons programs, which we have extended to produce a large array of practical tools and methods.

For example, the U.S. Environmental Protection Agency's (EPA) regulations for disposal of radioactive wastes are found in 40 Code of Federal Regulations (CFR) 191. The risk-based criteria for long-term (10,000-year) performance in 40 CFR 191 may be summarized in three questions:

- What can happen? (scenarios)
- How likely are these things to happen? (probabilities of scenarios)
- What are the outcomes of these things happening? (consequences of scenarios)

To answer these questions, Sandia applies the following general steps:

- Disposal system and regional characterization through data collection
- Scenario development
- Probability modeling
- Consequence analysis, including uncertainty analysis
- Regulatory compliance assessment by comparing modeling results with the performance criteria in 40 CFR 191
- Sensitivity analysis

Projects

The Waste Isolation Pilot Plant (WIPP), which commenced operation in March, 1999, near Carlsbad, New Mexico, is an underground repository for transuranic waste from defense programs. As the scientific advisor to the project, Sandia did performance assessment, disposal room and drift studies, experiments with waste, sealing and rock mechanics studies, development of hydrologic and transport models, quality assurance, and strategic planning.

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The Compliance Certification Application for the WIPP Project, which was based on 40 CFR 191, was submitted to the EPA in October, 1996. It relied heavily on the results of the Sandia work. Sandia used computer simulations to model the scenarios that may lead to radionuclide migration beyond a controlled boundary during the 10,000 period after wastes are emplaced and the WIPP repository is closed. The WIPP is the first (and currently only) mined geologic repository for nuclear waste in the United States.

The Yucca Mountain Project is investigating the suitability of a Nevada site for permanent disposal of spent fuel and high-level waste. Sandia does performance assessment, site characterization, laboratory and field testing, model development, design analysis, and extensive quality assurance and record keeping for the project. Sandia's performance assessments for Yucca Mountain follow the same basic steps described above. To show compliance with standards and regulations, the assessors estimate the probabilities of all the conditions that might produce significant releases from the repository and the consequences associated with those conditions. They combine the probabilities and the consequences into a single curve, a complementary cumulative distribution function (CCDF). The data describing the system and the conditions contain significant uncertainty, partly because they must describe conditions far in the future and partly because the characteristics of the system are complex. As a probabilistic measure of system performance, the CCDF incorporates the uncertainties and allows them to be taken into account explicitly.

The Greater Confinement Disposal (GCD) project evaluated the adequacy of using deep boreholes in alluvium at the Nevada Test Site (NTS) for waste disposal. The Department of Energy's (DOE) Nevada Field Office disposed of a variety of difficult radioactive wastes at the NTS in augered 10-ft-diameter and 120-ft-deep boreholes. Such disposal provides better isolation of radioactive waste than shallow land burial. Sandia performed a compliance assessment of the NTS GCD borehole disposal site relative to 40 CFR 191. The GCD compliance assessment process consisted of iterative analyses; iterations were based on sensitivity analyses of assessment results, used to define new data-collection activities. This ensured that data collection focused on the most significant safety issues. New data were incorporated into the next compliance assessment iteration.

Although 40 CFR 191 is an important driver for developing methods and analytical tools for evaluating long-term disposal of radioactive wastes, other regulations are important in assessing disposal of both radioactive and nonradioactive hazardous wastes. With minor modifications, the same modeling tools used for determining compliance with 40 CFR 191 could be used to assess compliance with other long-term environmental regulations, e.g., 40 CFR 268.

Other Decision-Support Projects

Smart Sampling™ is a decision-support tool for decision makers who must agree on a cleanup goal and the level of risk to accept in deciding on a remediation plan. The tool allows site owners, regulators, and other stakeholders to consider the effects of various action levels and risk tolerances on the ultimate cost remediation. A remediation plan that overestimates the degree of cleanup required to satisfy the action level results in unnecessary expense. A plan that underestimates the degree of cleanup may fail to achieve regulatory compliance, leading to fines, penalties, and more remedial actions. Smart Sampling™ quantifies the economic trade-offs between accepting higher levels of risk and lower remediation costs. In a 1996 demonstration at a lead-contaminated site at Sandia,

Smart Sampling™ produced four probability maps to help decision makers understand how a lower action level (400 ppm vs 2,000 ppm) and higher tolerance for risk (5% vs 1%) affected the amount of soil to be removed. The results showed that a remediation plan based on a 5% probability of leaving soil that exceeded an action level of 2,000 ppm could save $6.6 million over a plan with a 5% probability of exceeding the 400 ppm action level. Because all parties cooperated in setting cleanup and risk levels, the resulting remediation plan was defensible.

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